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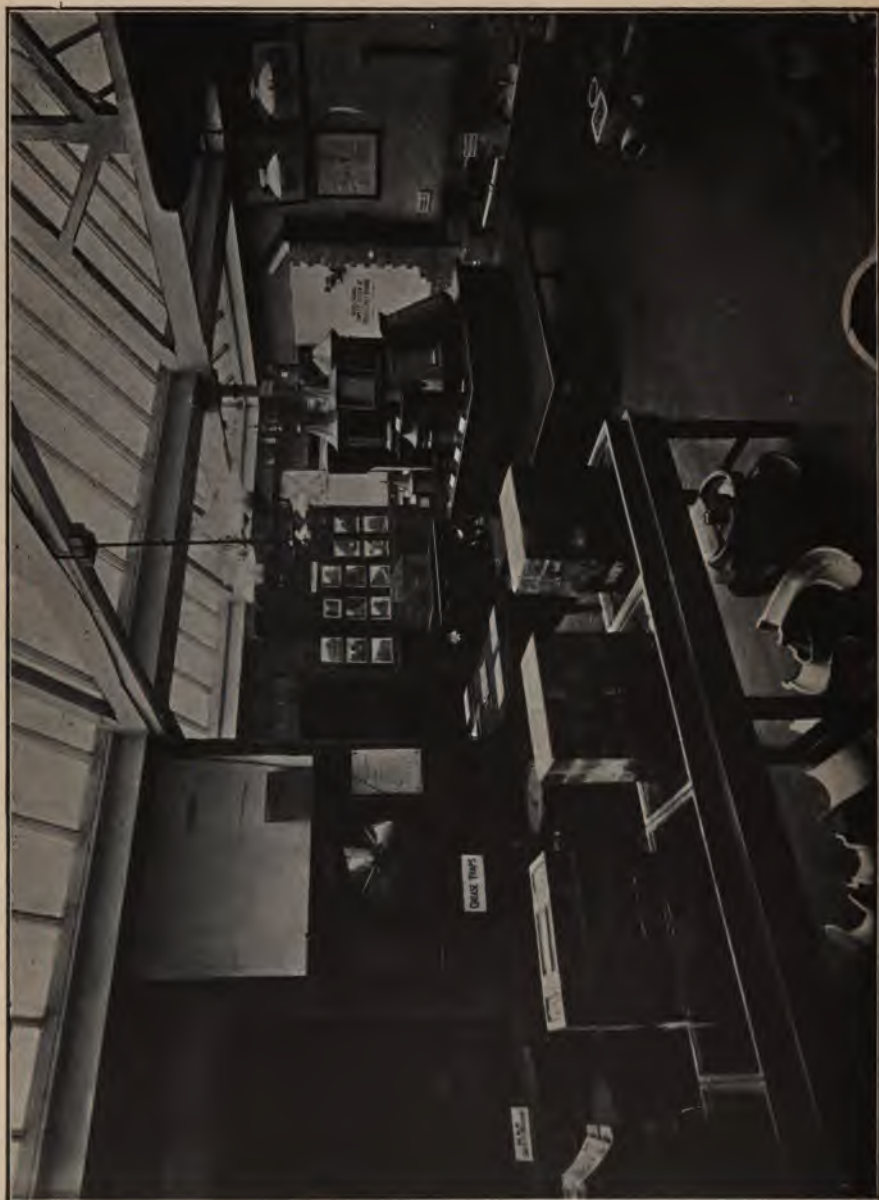
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**HANDBOOK OF THE
MUSEUM OF HYGIENE
UNIVERSITY COLLEGE LIVERPOOL**

**ARRANGED FOR THE USE OF
STUDENTS AND VISITORS**



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Medical Officer of Health

PREFACE

THE growing interest taken by people generally in the simple details of matters affecting health, have prompted a joint Committee of representatives of the City Council and the University College, designated the Sanitary Science Instruction Committee, to provide facilities by which some knowledge of the subjects may be acquired.

With this object in view, courses of instruction have been arranged, which are suitable for school teachers, surveyors, veterinary officers, and for persons desiring to qualify themselves for holding the appointment of Sanitary Inspector. Certificates are now required by almost every Sanitary Authority from candidates for appointment as Sanitary Inspectors, and in many cases such appointments will not receive the sanction of the Local Government Board unless the person appointed possesses a certificate of competency.

The courses of instruction provided by the Sanitary Science Instruction Committee are supplemented by practical demonstrations, but as it is desirable that the student should at all times have the means of examining the actual appliances and models connected with sanitation, or used in building construction, sewerage, drainage, water supply, ventilation, etc., a Museum or Exhibition has been established, the contents of which serve to fully illustrate the details of the subject.

The Committee are indebted to the family of the late Mr. George Holt for the museum building, to many donors for gifts of specimens which the museum contains, and to Messrs. Dent & Hellyer, Messrs. Bows, Scott & Western, Messrs. Twyford, and Mr. James Wilding for the use of blocks and illustrations contained in the Handbook.

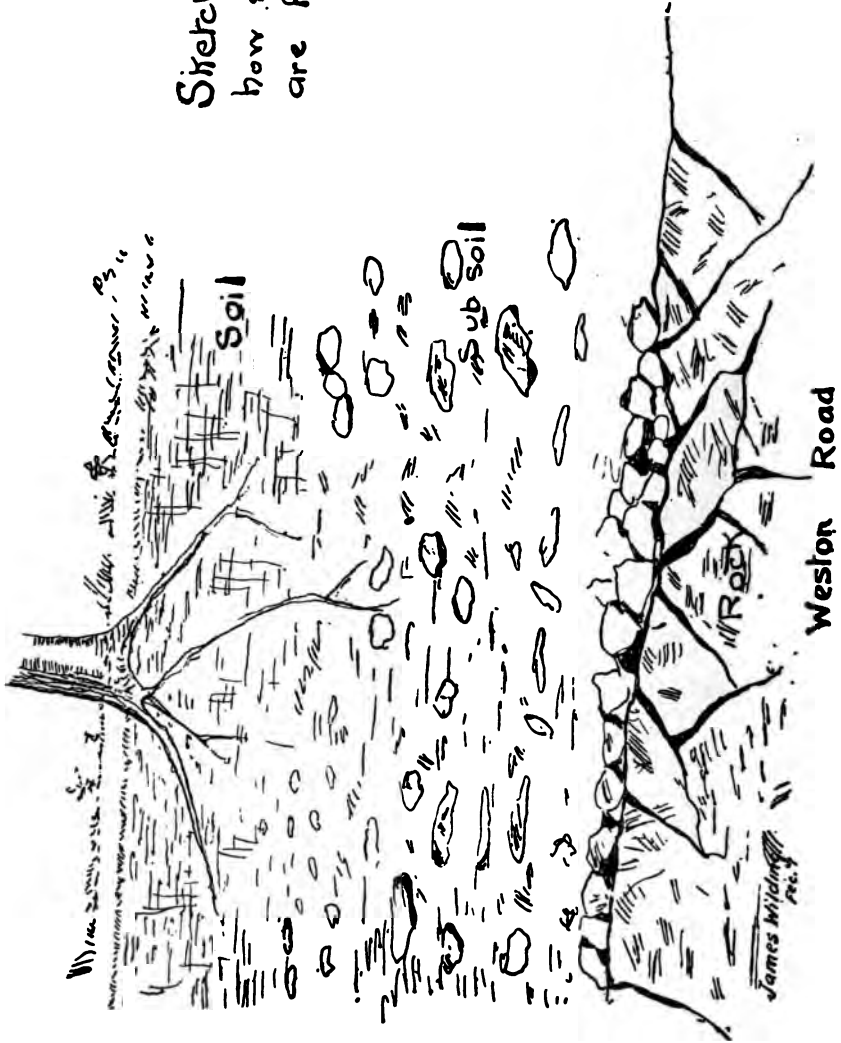
Sketch illustrating the Importance of the Concrete Site Covering.

This covering needs to be of the best quality when it overlies Filled up Ground



Sketch . Section through Boulder Clay and New Red Sandstone.

Sketch shewing
how subsoils
are formed.



NOTES ON SANITARY BUILDING CONSTRUCTION

SOILS

It is not often that towns offer much choice of soil—whatever geological condition is present has to be accepted and dealt with. Soils are usually tabulated in order of healthiness, following the table of Dr. Parkes :—

1. Primitive rock, clay slate, millstone grit.
2. Gravel and loose sands with permeable subsoils.
3. Sandstones.
4. Limestones.
5. Sands with impermeable subsoil.
6. Clays, marls, alluvial soils.
7. Marshes.
8. Filled up ground.

The under draining of damp sites is important.

The use of proper concrete in dealing with building sites that are at all doubtful is imperative if healthiness is to be secured.

FOUNDATIONS AND BASEMENTS

Basements are often very troublesome to keep dry.

Adequate foundation should be secured for all walls—where the ground is not sufficiently good concrete foundations should be formed on which to commence the footings of brick walls.

The use of the dry area is valuable round basements.

The open area used round basements should always be provided with outlet gully for rain water.

The horizontal damp-proof course of natural asphalte, combined with the vertical damp-proof course of same material, is very effective in dealing with damp sites.

The whole basement area should be covered with Callender's bitumen, or with val-de-travers, or similar asphalte in such site as the one referred to above.

LAYING OUT STREETS AND BUILDING SITES

To ensure a town in accordance with sanitary principles, the following conditions are necessary, but rarely present :—

Situation with levels of such a nature as to readily admit of dealing with the sewage by gravitation.

Adequate outlet with sufficient area for sewage treatment and means of disposal of effluent.

The subsoil and surface soil should be of the first four named in the list.

Streets should run obliquely to points of compass, *i.e.*, north-east and south-west and north-west and south-east.

No cul-de-sacs or courts should be allowed.

All squares should be open at corners.

No street should be of less width than forty-two feet.

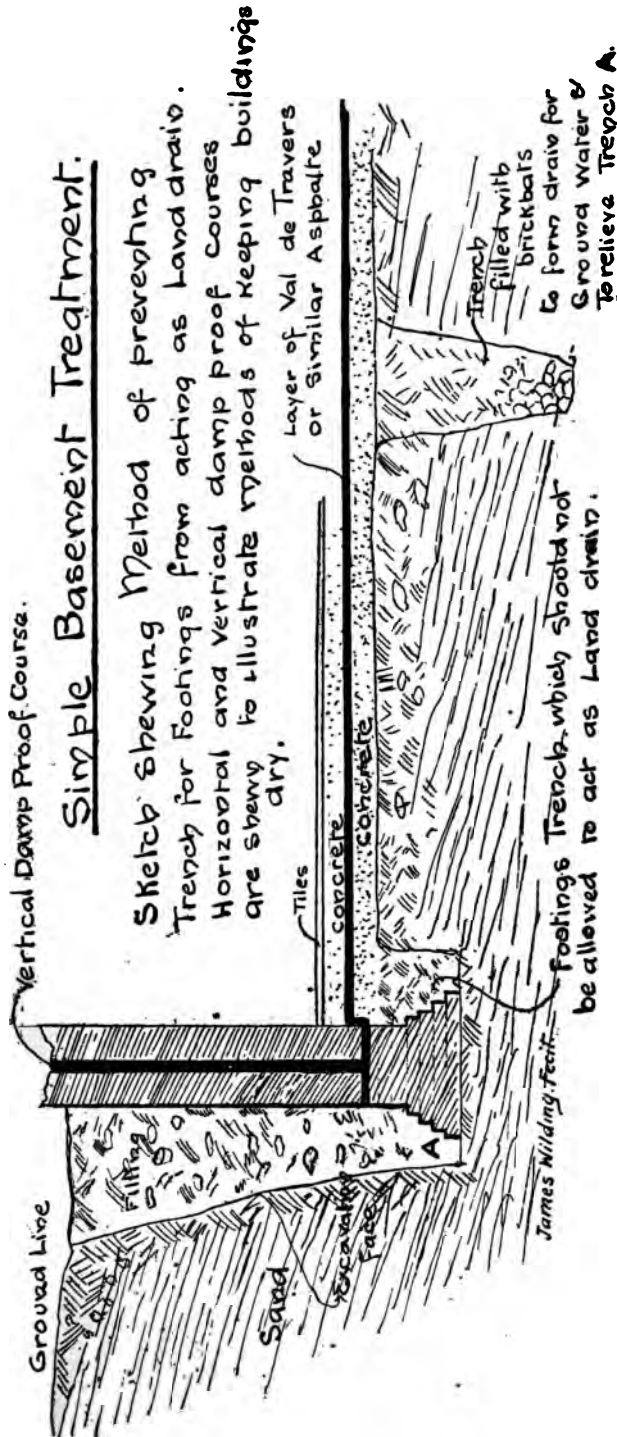
No back passages should be less than ten feet wide.

A complete system of sewers should be arranged, with as much regard to future expansion as is reasonable.

Sewer ventilation should be fully considered.

Estates are usually developed commercially.

The utmost skill is called into use in dealing with the fusing of old towns with new suburbs.



Simple Basement Treatment.

Sketch shewing Method of preventing
Trench for Footings from acting as Land drain.
Horizontal and Vertical damp proof Courses
are shown to illustrate methods of keeping buildings
dry.

Layer of Val de Travers
or similar Asphalte

Tiles

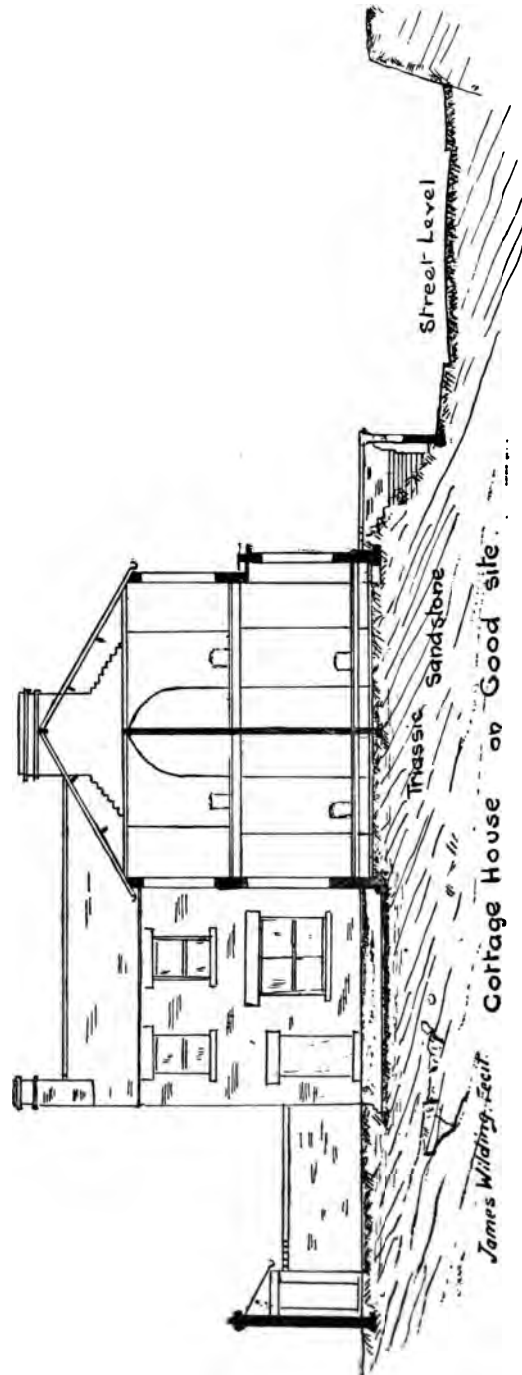
concrete

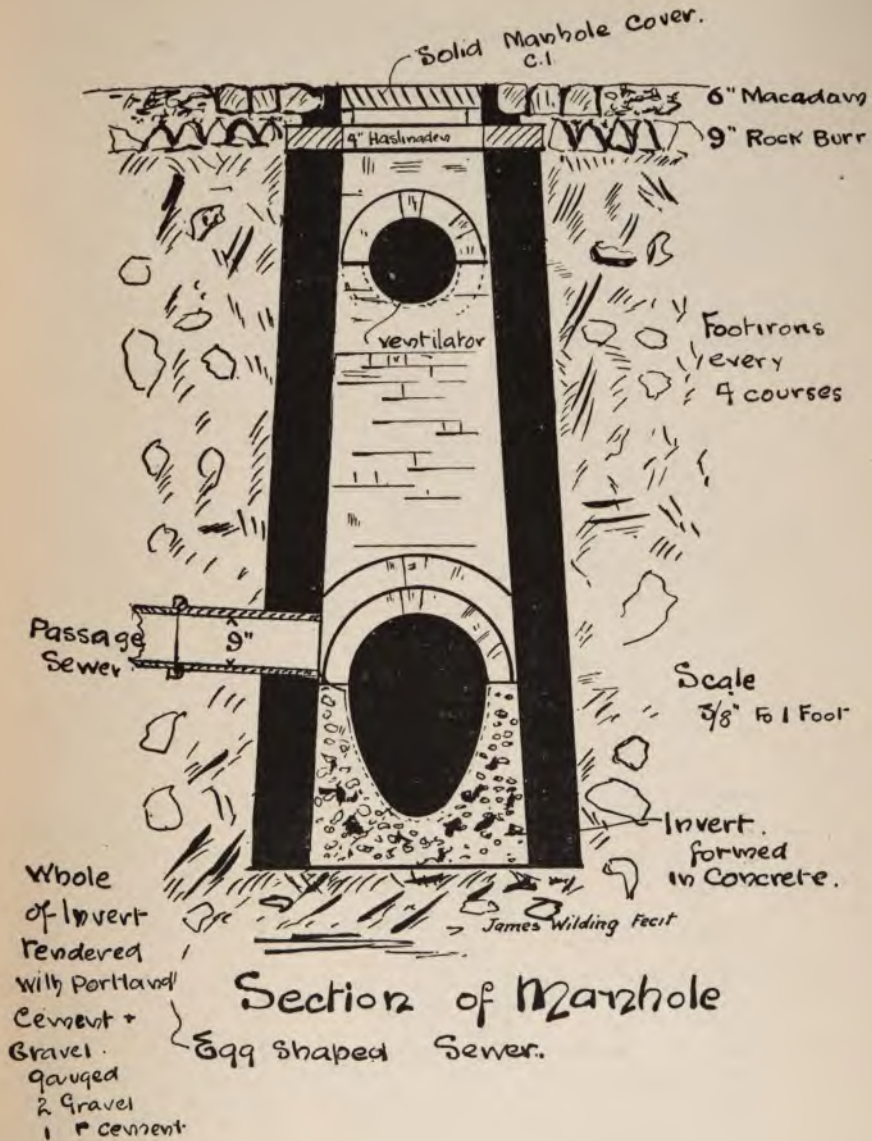
Trench
filled with
bricks

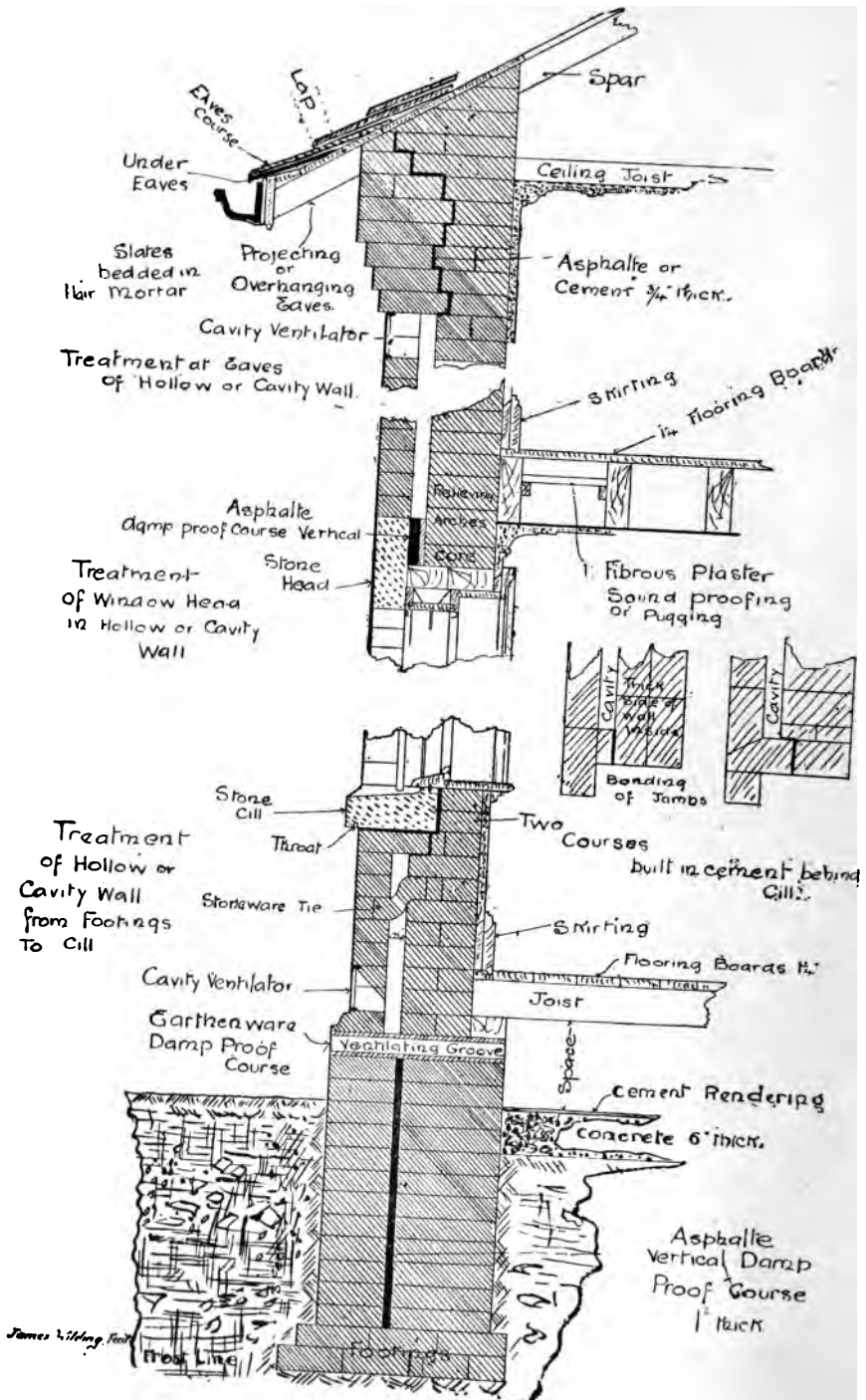
to form drain for
Ground Water &
to relieve Trench A.

Footings Trench, which should not
be allowed to act as Land drain.

James Nielding. Feat.







The Local Government requirements for new streets are given under the heading of 'Bye-laws'—these should be regarded as the minimum.

LOCAL GOVERNMENT BYE-LAWS

Every person who shall erect a new domestic building shall cause the whole ground surface or site of such building to be properly asphalted or covered with a layer of good cement concrete, rammed solid, at least *six inches* thick, to prevent the rising of ground air and ground water.

BRICK EARTHS. TERRA-COTTA BRICKS AND WALLING

Common bricks used in Liverpool are mostly made from the local deposit of boulder clay.

To make good bricks there should not be an excess of limestone in the clay.

A good brick should ring when struck by a trowel.

Walls should be solidly built of good materials properly bonded together. Hollow walls should be tied together with proper ties every eighteen inches vertically, and three feet horizontally. All 'voids' in terra-cotta should be filled with concrete. Walls comply with the Local Government Board Bye-laws if they are built of stone, brick, or concrete.

No external wall, party wall, or cross wall shall be less than nine inches thick if of brick or regular blocks of stone.

If of materials such as random rubble or clunches of bricks or of flint, the thickness of such walls shall be one-third thicker than that prescribed for by the bye-law having reference to wall of brick of a given length and height.

All walls should have footings equal in width to twice the width of the wall at its base, and equal to two-thirds thickness of wall at base in depth.

All joints in walls should be well flushed up with good mortar as the work proceeds.

Bricks and stones should be adequately bedded to ensure a solid wall. Three-sixteenths of an inch to one-quarter of an inch ensures this.

Local Government Board Bye-laws require the following thickness for walls of dwelling-houses for the lengths and heights given hereafter.

WALLS

Max. Height	Max. Length	1st storey	2nd storey	3rd storey	4th storey	5th storey
Up to 25 feet	30 feet	9 in.				
„ 30 „		13½ in.	9 in.			
„ 40 „	35 „	13½ in.	13½ in.	13½ in.	9 in.	
„ 46 „	Unlimited length	18 in.	13½ in.	13½ in.	9 in.	

ROOF CONSTRUCTION

Roofs should be covered with incombustible material.

Slates and tiles form the usual coverings. These should be laid with not less than three-inch lap, and should be properly tierced with hair mortar when on open battens. Copper nails are used, but composition nails are best in good class work. Walls should be carried up to underside of slates.

In the best work felt is used in addition to slates or tiles, the roof being felted on top of the boards. All chimney stacks, parapet walls, and gable walls should be properly flashed with under and cap-flashing of lead. Ridge rolls and hip rolls may be covered with lead.

If terra-cotta ridging and hiping be used, each piece should be properly bedded in gauged lime and hair mortar, and jointed in cement. Lead is used for covering level roofs or flats.

Copper is also used, but not so frequently.

PLASTERING AND INTERNAL TREATMENT OF WALLS

The greatest care should be observed to ensure clean and good material.

No road drifts should be allowed to be used as substitute for sand. Lime should be specially run for the purpose.

PLUMBING

This most important branch should be carried out in the best possible manner.

Wiped joints should be used throughout.

All drawn lead pipes should be the proper weights.

All fittings should be trapped and ventilated.

VENTILATION, WARMING, AND LIGHTING

Ventilation—The aim of ventilation is the removal and dispersion of impurities which have accumulated in the atmosphere as the results of such vitiating processes as respiration, combustion of fuel, etc.

There are various means taken to attain this end, and they are usually divided into two classes, viz. :—

1. Natural ventilation, which makes use of the natural forces at our disposal, such as wind and difference in weights of hot and cold air and of dry and moist air.

2. Artificial ventilation, which depends on artificial agencies, such as furnaces, combustion of gas, hot-water pipes, fans, steam jets, etc.

In ventilation of dwelling-houses natural means are chiefly relied upon, supplemented by the extracting forces of an open fire.

In public rooms, large halls, or in factories or workshops, it is usually necessary to have some system of artificial ventilation, owing to the greater degree of vitiation in the atmosphere.

Warming.—The heating of rooms is very closely connected with the methods of ventilation, as heat is the chief agency employed in ventilating enclosed spaces.

This is carried out in a variety of ways, the most common in this country being the familiar coal fire. Its advantages are that it warms the room by radiation, and aids materially in the ventilation. The disadvantages are, extravagant use of fuel and lack of uniformity in heating the various parts of the room. Among the best fire-grates are those after the design of Mr. Teale, examples of which are fitted up in the museum. Other means of heating rooms are stoves for burning coal or coke, gas stoves, oil stoves, hot-water pipes, and hot air.

The last two methods are used chiefly for large public rooms and such like places, as the waste of fuel is less in one large furnace than in several small fires, and the heating is more uniform.

Lighting.—Artificial lighting of rooms is provided by means of candles, paraffin-oil lamps, gas, and electric light.

The following table shows some of the effects that the various methods of lighting have upon the air of the room :—

	Candle power	Oxy. removed	CO ₂ added	Heat in Colonies
Sperm candles	16	9·6 c. ft.	6·5 c. ft.	1137
Paraffin-oil lamp	16	6·2 „	4·5 „	1030
Coal gas, batwing burner	16	6·5 „	2·8 „	1194
„ Welsbach	50	4·1 „	1·8 „	763
Electric light, incandescent	16	0·0 „	0·0 „	37

From the above it is apparent that the incandescent form of electric light is by far the most suitable for domestic use, and the Welsbach is the most satisfactory method of using coal gas.

METEOROLOGICAL INSTRUMENTS

Thermometers

1. Self-registering maximum thermometer. A small bend or constriction is made just above the bulb ; this prevents the mercury being drawn back when the temperature falls.

2. Self-registering minimum thermometer. Alcohol is usually used in this instrument. A small index is placed in the column ; this is drawn inwards as the alcohol contracts, it, however, retains its position when the alcohol expands.

3. Sixes' combined maximum and minimum thermometer. Made in the form of a **U**, both alcohol and mercury used, and by means of an index in each limb

the maximum and minimum temperatures are registered.

This instrument must be kept in an upright position.

4. Solar radiation thermometer, for measuring the strength of the sun's rays. A maximum thermometer with blackened bulb, to prevent loss of heat by reflection, and enclosed in a glass case to prevent the cooling action of the wind.

5. Terrestrial radiation thermometers, for measuring the radiation of the heat from the earth.

A minimum thermometer, to be placed close to the ground.

6. Ground thermometer, for recording the temperatures at different depths below the surface of the ground.

Barometers

For measuring the pressure of the atmosphere.

1. Standard mercurial barometer, in which a column of mercury about thirty inches in height is used to measure the variation in the pressure.

2. Aneroid barometers, in which a chamber partially exhausted of air is made to record the variation in the pressure.

Wet and dry bulb hygrometer, for ascertaining the amount of moisture in the air, consists of two similar thermometers placed side by side ; one bulb is exposed directly to the air, the other is covered with a piece of muslin, which is kept damp with water.

The evaporation from the wet bulb lowers the temperature in that thermometer, and the evaporation in turn varies according to the amount of moisture in the air. Consequently if the difference between the wet and dry bulb thermometers be noted the amount of moisture in the air can readily be calculated.

Sunshine recorder, for registering the number of hours during which the sun actually shone. The record is made on a piece of sensitized paper, on which, when the sun shines with sufficient intensity, a line is traced.

Rain gauge, for measuring the amount of the rainfall, consists usually of a cylindrical copper vessel, with a funnel opening on top to collect the rain. The amount is measured by a measuring glass, which gives the number of inches or fractions of an inch that has fallen.

ROOM A

The model of house drainage should be first examined, many of the loose fittings being appliances and specialities of various makers for similar purposes, *i.e.*, the ensuring of good sanitary detail. The sketch on the opposite page indicates the principal features of the model. A section is shewn of an egg-shaped sewer, with a Staffordshire blue brick invert. The formation of an impervious carriageway with granite sett paving grouted with asphalte and laid on a bed of concrete overlies the section of sewer.

The curb and channel are both of granite, and the footway is granolithic concrete.

The section of gully shewn clearly illustrates the expedient adopted to remove any blocking that may take place in the trap of the gully without the cost attendant upon pulling up the carriageway.

A 'lamp hole' and ventilating grating is shewn in the crown of the road.

The drain from the curtilage of the property, as well as the gully outlet, is shewn by the concrete being left out in two places. Sections of electric wires and of water and gas pipes are shewn. The curtilage wall is built of local bricks, with Ruabon brick on edge coping. It is built in English bond, and is toothed to indicate that it is part of a continuous enclosure wall. The interceptor is shewn next to this wall, and is placed with the mouth in an intercepting chamber, and with a raking cleansing arm with stanford jointed stopper coming into same chamber, the said chamber being

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built of white enamelled bricks backed up with common bricks. The bottom of the chamber is formed in concrete, with white glazed enamelled half-pipes. The house drain enters it, and, in addition thereto, the gully drain and an auxilliary drain is shewn, connexion to the straight half-channel being by Winsor's 'channel bends,' the object of the latter invention being to prevent sewage piling on the banks of the interceptor bottom. The chamber is covered with an air-tight cover with luted rim. The air supply is by means of a four-inch pipe taken up the side of the adjacent wall from a point below the air-tight cover—a mica air inlet valve caps this pipe—its object is to prevent puffs of drain air caused by passing sewage from being delivered at a level likely to be objectionable.

Portion of the outside walls of a bath-room is shewn built in English bond ; below the damp-proof course of asphalte the bricks are of local make, above they are Ruabon. The wall has been omitted between the toothings to shew bath waste, and the house wall shewn in toothed section in order to shew an inside watercloset.

This basin, which is a wash-down 'deluge,' is of Twyford's make, and is connected to the vertical lead soil pipe by means of a screw joint. This soil pipe is jointed to the four-inch stoneware drain by means of a thimble, and is surmounted by a lead terminal. The basin is provided with an anti-syphonage trap and terminal ; from the position of the soil pipe it is possible to use it as an outlet ventilator to the drainage system.

The four-inch spigot and socket stoneware drain is laid on concrete (of gravel and cement) throughout its length, one portion being covered with a block of concrete to illustrate the best method of forming drains. The drain has an inclination of one in thirty-six ; it is

provided with an inspection junction, which is used to illustrate the method of examining a drain by the mirror test. A light is placed in the pipe at the said junction, and a mirror is inclined at 45° in the half channels of the intercepting chamber; on looking vertically upon the mirror the whole of the pipe interior is seen. The pipes are jointed with cement and sand gauged one to one.

The two-inch bath waste is shewn trapped, and connected with the open channel recommended by the Local Government Board by means of a two-inch drawn lead waste pipe; a side cleansing screw is placed in the trap of bath waste.

The three-inch downspout is also shewn emptying into the channel named above; the channel is connected by a spigot to a self-cleansing trap, and by four-inch pipes to the intercepting chamber.

The Local Government Bye-laws on which the above model is constructed are as follows :—

With respect to the drainage of buildings

DRAINAGE OF SUBSOIL

Every person who shall erect a new building shall cause the subsoil of the site of such building to be effectually drained by means of suitable earthenware field pipes, properly laid to a suitable outfall, whenever the dampness of the site renders such a precaution necessary.

He shall not lay any such pipe in such a manner or in such a position as to communicate directly with any sewer or cesspool, or with any drain constructed or adapted to be used for conveying sewage, but shall provide a suitable trap, with a ventilating opening, at a point in the line of the subsoil drain as near as may be practicable to such trap.

DOWN SPOUTS

PREVENTION OF DAMP IN ANY PART OF WALL OR
FOUNDATION

Every person who shall erect a new building shall cause a suitable pipe or trunk, extending from the roof of such building to the ground, to be fixed to the front or rear or to one of the sides of such building, and to be so connected with a gutter, shoot, or trough receiving any water that may fall on the roof as to carry all such water therefrom without causing dampness in any part of any wall or foundation of such building.

Every person who shall erect a new building shall construct the lowest storey of such building at such level as will allow of the construction of a drain sufficient for the effectual drainage of such building, and of the provision of the requisite communication with any sewer into which such drain may lawfully empty, at a point in the upper half diameter of such sewer, or with any other means of drainage with which such drain may lawfully communicate.

Every person who shall erect a new building shall, in the construction of every drain of such building, other than a drain constructed in pursuance of the by-law in that behalf for the drainage of the subsoil of the site of such building, use good sound pipes formed of glazed stoneware, or of other equally suitable material.

He shall cause every such drain to be of adequate size, and, if constructed or adapted to be used for conveying sewage, to have an internal diameter of not less than *four inches*, and to be laid in a bed of good concrete, with a proper fall, and with water-tight, socketed, or other suitable joints.

He shall not construct any such drain so as to pass under any building, except in any case where any other mode of construction may be impracticable, and in that case he shall cause such drain to be so laid in the ground that there shall be a distance equal at least to the full diameter thereof between the top of such drain at its highest point and the surface of the ground under such building.

He shall also cause such drain to be laid in a direct line for the whole distance beneath such building, and to be completely embedded in and covered with good solid concrete, at least *six inches* thick all round.

He shall likewise cause adequate means of ventilation to be provided in connexion with such drain at each end of such portion thereof as is beneath such building.

He shall cause every inlet to any drain, not being an inlet provided in pursuance of the bye-law in that behalf as an opening for the ventilation of such drain, to be properly trapped.

Every person who shall erect a new building and provide within the curtilage thereof, in every main drain or other drain of such building which may directly communicate with any sewer or other means of drainage into which such drain may lawfully empty, a suitable trap at a point as distant as may be practicable from such building, and as near as may be practicable to the point at which such drain may be connected with such sewer or other means of drainage.

A person who shall erect a new building shall not construct the several drains of such building in such a manner as to form in such drains any right-angled junction, either vertical or horizontal. He shall cause

every branch drain or tributary drain to join another drain obliquely in the direction of the flow of such drain.

Every person who shall erect a new building shall, for the purpose of securing efficient ventilation of the drains of such building, comply with the following requirements :—

(i) He shall provide at least two untrapped openings to the drains, and, in the provision of such openings, he shall adopt such of the two arrangements hereinafter specified as the circumstances of the case may render the more suitable and effectual.

(a) One opening, being at or near the level of the surface of the ground adjoining such opening, shall communicate with the drains by means of a suitable pipe, shaft, or disconnecting chamber, and shall be situated as near as may be practicable to the trap which, in pursuance of the bye-law in that behalf, shall be provided between the main drain or other drain of the building, and the sewer or other means of drainage with which such drain may lawfully communicate. Such opening shall also in every case be situated on that side of the trap which is the nearer to the building.

The second opening shall be obtained by carrying up from a point in the drains, as far distant as may be practicable from the point at which the first-mentioned opening shall be situated, a pipe or shaft, vertically, to such a height and in such a manner as effectually to prevent any escape of foul air from such pipe or shaft into any building in the vicinity thereof, and in no case to a less height than *ten feet*.

(b) In every case where the foregoing arrangement of the openings to the drains may be impracticable, there shall be substituted the arrangement hereinafter prescribed.

One opening shall be obtained by carrying up from a point, as near as may be practicable to the trap, which, in pursuance of the bye-law in that behalf, shall be provided between the main drain or other drain of the building and the sewer or other means of drainage with which such drain may lawfully communicate, a pipe or shaft, vertically, to such a height and in such a manner as effectually to prevent any escape of foul air from such pipe or shaft into any building in the vicinity thereof, and in no case to a less height than *ten feet*. Such opening shall also in every case be situated on that side of the trap which is the nearer to the building.

The second opening, being at a point in the drains as far distant as may be practicable from the point at which such last-mentioned pipe or shaft shall be carried up, shall be at or near the level of the surface of the ground adjoining such opening, and shall communicate with the drains by means of a suitable pipe or shaft.

(ii) He shall cause every opening provided in accordance with either of the arrangements hereinbefore specified to be furnished with a suitable grating or other suitable cover, for the purpose of preventing any obstruction in or injury to any pipe or drain by the introduction of any substance through any such opening. He shall, in every case, cause such grating or cover to be so constructed and fitted as to secure the free passage of air through such grating or cover by means of a sufficient number of apertures, of which the aggregate extent shall be not less than the sectional area of the pipe or drain to which such grating or cover may be fitted.

(iii) Every pipe or shaft which may be used in connexion with either of the arrangements hereinbefore specified shall be of a sectional area not less than that

of the drain with which such pipe or shaft may communicate, and not less in any case than the sectional area of a pipe or shaft of the diameter of *four inches*.

(iv) No bend or angle shall (except where unavoidable) be formed in any pipe or shaft used in connexion with either of the arrangements hereinbefore specified.

(v) Provided always, that for the purpose of either of the arrangements hereinbefore specified the soil pipe of any water closet, in every case where the situation, sectional area, height, and mode of construction of such soil pipe shall be in accordance with the requirements applicable to the pipe or shaft to be carried up from the drains, may be deemed to provide the necessary opening for ventilation which would otherwise be obtained by means of such last-mentioned pipe or shaft.

A person who shall erect a new building shall not construct any drain of such building in such a manner as to allow any inlet to such drain (except such inlet as may be necessary from the apparatus of any water closet) to be made within such building.

He shall cause the soil pipe from every water closet in such building to be at least *four inches* in diameter, and to be fixed outside such building, and to be continued upwards without diminution of its diameter, and (except where unavoidable) without any bend or angle being formed in such soil pipe to such a height and in such a position as to afford, by means of the open end of such soil pipe, a safe outlet for sewer air.

He shall so construct such soil pipe that there shall not be any trap between such soil pipe and the drains, or any trap (other than such as may necessarily form part of the apparatus of any water closet) in any part of such soil pipe.

He shall also cause the waste pipe from every bath, sink (not being a slop sink constructed or adapted to be used for receiving any solid or liquid filth), or lavatory, the overflow pipe from any cistern and from every safe under any bath or water closet, and every pipe in such building for carrying off waste water to be taken through an external wall of such building, and to discharge in the open air over a channel leading to a trapped gully grating at least *eighteen inches* distant.

He shall, as regards the mode of construction of the waste pipe from any slop sink constructed or adapted to be used for receiving within such building any solid or liquid filth, comply in all respects with such of the provisions of this bye-law as are applicable to the soil pipe from a water closet.

DRAINAGE SHEWN IN SITU

The various gullies are covered with glazed lids, and will be seen in floors of museum. All drains are taken into the inspection chamber in the middle of the room. This is covered first with a luted air-tight cover, and then with a section of flooring. Into this chamber the outlet from the experimental trench leads. This trench, which is indicated on plan, is used for the purpose of demonstrating good methods and bad methods of laying drain pipes, and for water and smoke-testing of same. It is constructed of concrete with a fall of one in thirty-six, and is covered with movable sections of the floor.

The walls of the room are left to illustrate methods of bonding bricks, forming window and door openings, construction of five casement lights and one N. A. P. window.

Methods of covering walls with plaster, panelling, tiling and of glazed brick finishing.

The roof is of glass, and the ventilation is by means of a Boyle's extractor and several makes of inlets.

- No.
1. Flemish bonded brick panel.
 2. " " " " „ Aston Hall buff brick.
 3. Stretching „ „ „ „ St. Helen's bricks.
 4. Old English bonded brick panel in Liverpool common bricks.
 5. Wall shewing modified English bond.
 6. Model of wall without damp-proof course resting in water since 1898.
 7. Model of wall with slate and cement damp-proof course in water since 1898.
 8. Model of wall with vitrified ventilating damp-proof course.
 9. Model of wall with artificial asphalte horizontal and vertical damp-proof course (used for basements and damp sites).
 10. Model of wall with two and one-quarter cavity, and artificial asphalte damp-proof course.

Attention is drawn to the saltpetreing or efflorescence on the various models of damp-proof course. The value of damp-proof courses is strongly emphasized. Saltpetreing arises from damp, action of fuel used in brick burning on iron pyrites, and other sources.

Imperfectly built walls, *i.e.*, walls not solidly flushed with mortar in the interior joints, often shew this defect.

DRAIN PIPES, BENDS, GULLIES

The material used for making these should be of a non-porous character, as far as is practicable. The

proper and adequate glazing of the pipe to assist its impermeability.

Pipes are made of—

- (a) Unglazed earthenware for field or agricultural drains, used for subsoil drains.
- (b) The clays of the coal measures, called fire-clay.
- (c) Stoneware, which is practically prepared on the lines of pottery clay, and consists of the Lias formation mixed with ground calcined flints and decomposed Cornish granite. It is the best material for sanitary ware.
- (d) Terra-cotta, made from Permian clays, not so dense as stoneware.

Glazing is done in several ways—salt-glazing is carried out by throwing salt into the kilns when they are at a high temperature—result, glaze forms on wares in a glass-like manner.

Lead glazing is usually applied in the 'biscuit' stage of manufacture, *i.e.*, first burning by dipping in bath of oxide lead and tin, etc.

Drain pipes should be straight and true and free from firecracks.

- 11. 4-inch and 6-inch spigot and socket drain pipes.
- 12. 4-inch and 6-inch spigot and socket drain pipes with Stanford joint.
- 13. Albion Clay Company screw joint.
- 14. Hassall's single joint.
- 15. Hassall's double joint.
- 16. Ames crosta.

Common joints in drain pipes are made with Portland cement and clean, sharp sand gauged one part Portland cement and one part sand.

Drain Pipes.



Half Pipe



Pipe with Inspection Eye

Oblique Junction



Inspection Junctions



Y Junction



Half Junction



Inspection Bends



Double Junction



Taper Pipe



Taper Pipe



Taper Pipes



Saddle Junction



Piece



Vent Bend with Cleansing Eye



Rest Bend.

Gully Traps



Self Cleansing Types



Self Cleansing Traps
Loose Tops

Angle Outlet



Side Inlet



Trap with
Loose
Top and
Mud
Basket

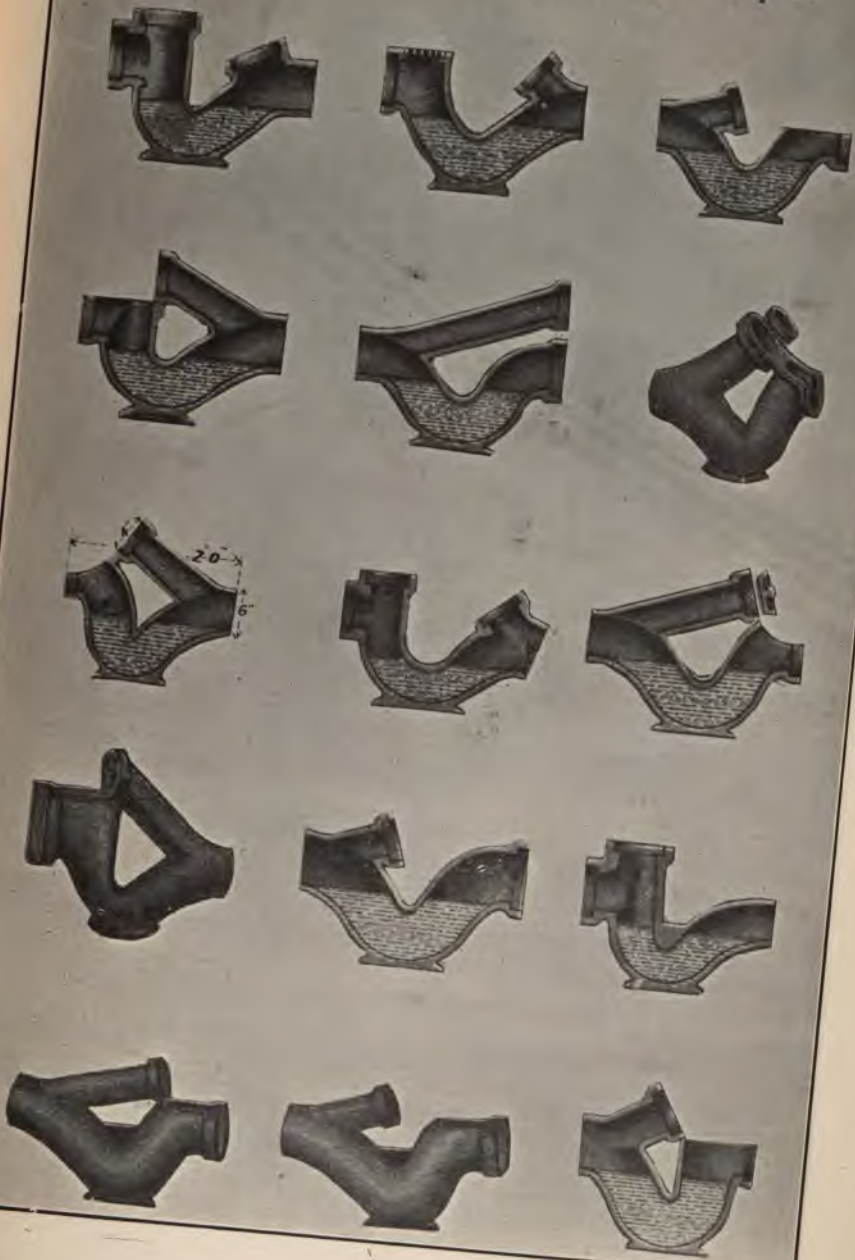


Square
Trap
with
Mud
Basket



Square
Type

TYPES of Intercepting Traps.



Patent joints are usually of the same material as the Stanford patent, *i.e.*, a mixture of coal-tar, sulphur, and ground pipes, which are cast truly on the spigot and socket ends of the pipes, and make a water-tight joint without cement. Russian tallow and resin or a special preparation supplied by each manufacturer is used to grease the joints as they are put together.

The double joints (15 and 16) provide space for cement joint in addition.

MacFarlane's glass-lined soil pipe with lead joints.
Iron pipe with spigot and socket joints and of water-main strength.

JUNCTIONS

All Junctions should be oblique, *i.e.*, not at right angles to the flow.

17. Single Junctions.
18. Double Junctions or Y Junctions.
19. Inspection Junctions.
20. Junctions with three inlets.

BENDS

Bends are made of all radii.

They obviate any sharp angles in drains. The knuckle or sharp bend is soon choked. All bends should be easy, and should have a little more fall than the straight lengths of drain they connect. It is better to use two slow bends than one quick one.

Rest bends for the reception of soil pipes are an improvement on the old type.

21. Quick bend.
22. Slow „
23. Taper „
24. Rest „
25. Rest Bend Junction.
26. Inspection Bend.

INTERCEPTORS

The position of the Interceptor is shewn in the House Drainage Model.

Its work is to cut off the house drainage from any attack of sewer gas.

It is sometimes placed at the foot of soil pipes; except in places where water closets are seldom used this is not wise.

27. The 'Winser.'
28. Improved Kenon—Cliff's.
29. The Waverley—Cliff's.
30. Doulton's Fig. 38, with four-inch and six-inch outgo.
31. Common form.
32. Obsolete form condemned because of central shaft.
33. The Beanciff—Cliff's.
34. The Salus—Cliff's.
35. 'Pipe shaft.' Cast iron drain trap—Dent and Hellyer's.
36. Drain sentinel.

Features of good interceptor (syphon or drain sentinel are alternative names).

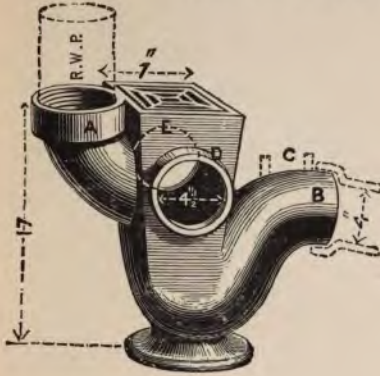
Effective seal when filled with water.

Concentration of flush.

Easy outgo—easy access.

41. Dent and Hellyer's 'soil pipe' syphons.
42. Cliff's 'Potts trap' " "
43. Ile's patent " "
- Cregeen air inlet—Doulton's.
- Mushroom air inlet—Dent and Hellyer's.

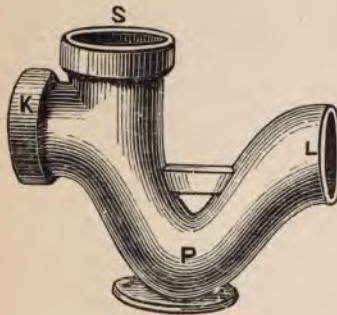
HELLYER'S DRAIN SPECIALITIES



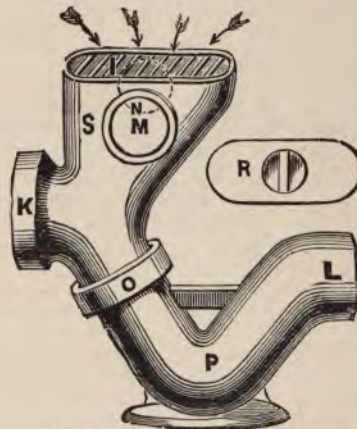
Interceptor



Interceptor



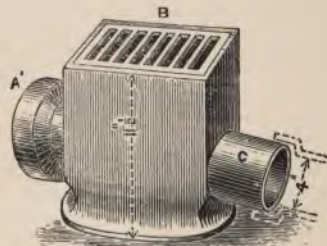
Interceptor



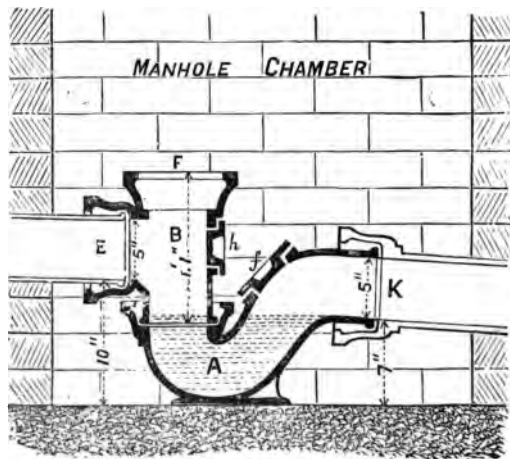
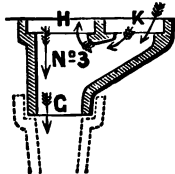
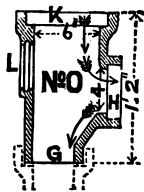
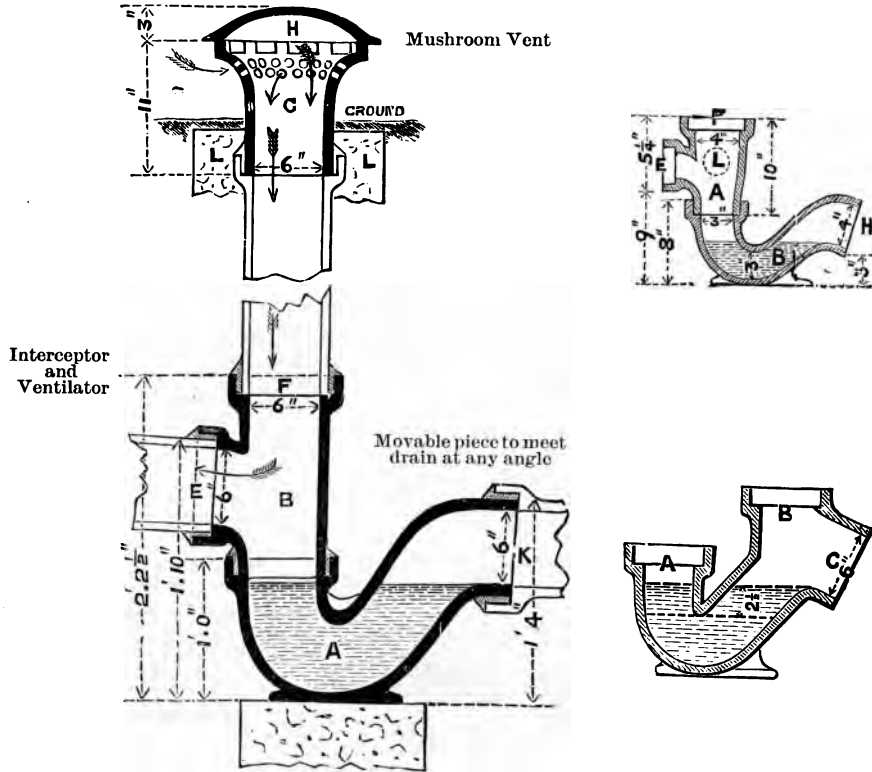
View 6-in. Ventilating Interceptor



Interceptor with Inlet Arms

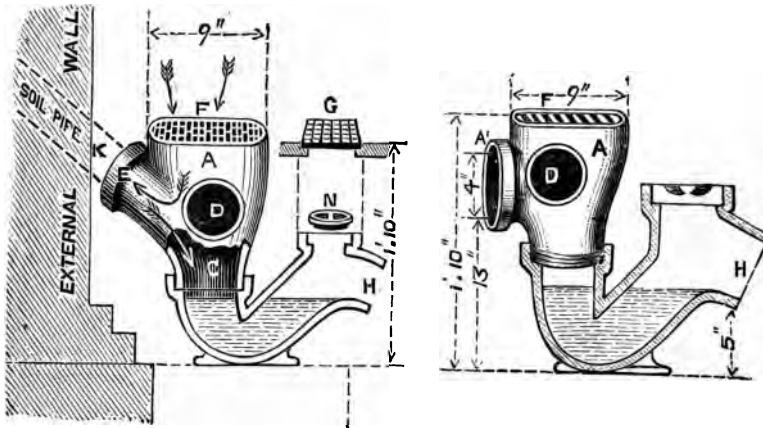


Air Shaft for 4-in Drain

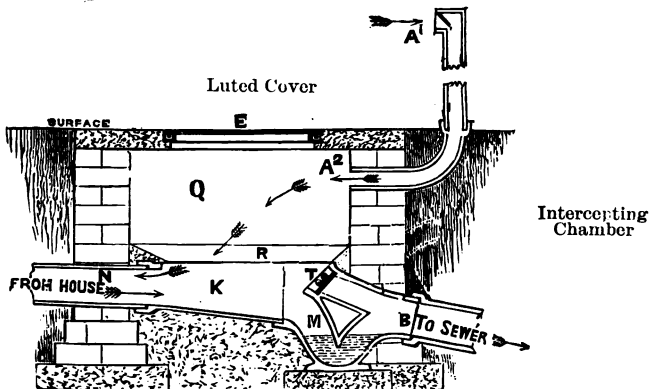


Cast-Iron Interceptor in Chamber

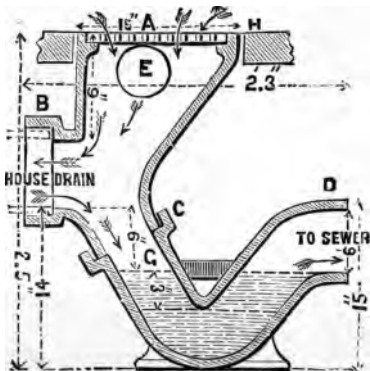
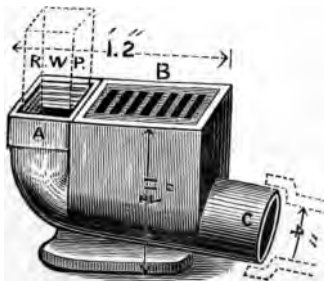
TYPES OF INTERCEPTORS



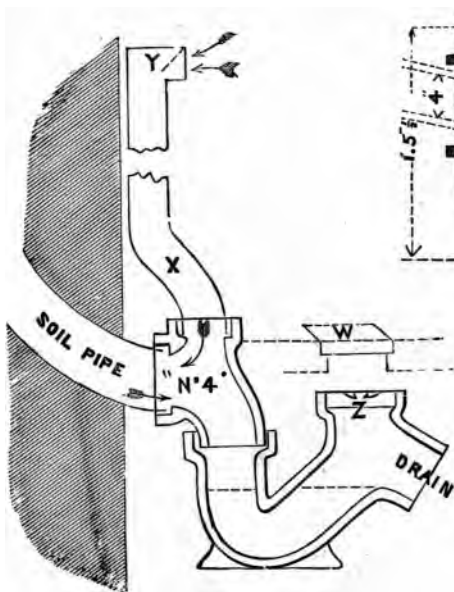
Interceptor



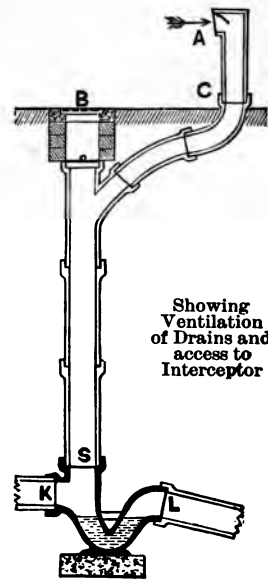
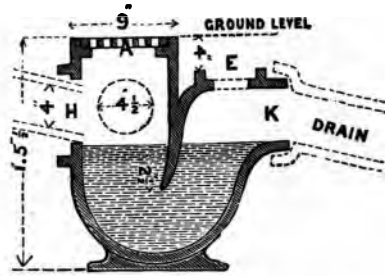
Intercepting Chamber



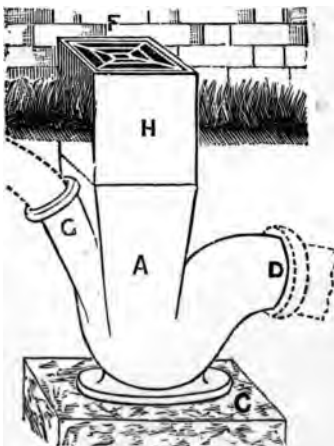
Section 6-in. Interceptor



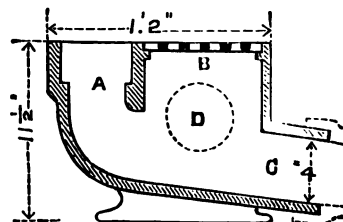
Shewing Ventilator Interceptor at foot of Soil Pipe



Showing Ventilation of Drains and access to Interceptor



Interceptor, with Heightening Pipe



Rain-water Shoe

METHODS OF CONTROLLING DRAINS OTHER THAN BY BRICK CHAMBERS, WHICH ARE EXPENSIVE

Mooney's access fittings give good working control by means of columns of vertical pipes over specially designed pipes, junctions, and bends.

41. Mooney's access pipe.
42. Cliff 'iron inspection junction,' in combination with Waverley syphon, is of good character and ensures effective control.

Manhole inverts and inspection chamber inverts to take similar place to that in the model intercepting chamber.

- | | | | |
|-----|---|-------------------|----------------------|
| 43. | { | 'Wyvurst' invert. | |
| | | „ | left hand junction. |
| | | „ | right hand junction. |
| | | „ | double inlet. |
| | | „ | single inlet. |
| | | „ | terminal. |

Bends.

Junctions.

Half-pipes.

Channel pipe.

DOULTON CHANNEL PIPE

- { Doulton's yard gully with bend for rain water-
 pipe ; self cleanser.
 { Doulton's yard gully ; self cleanser.
 " round gully for yard.
 " gully with extended sides to
 prevent splashing ; self
 cleanser.
 { Mooney's 'Clarence' self-cleanser rain water
 gully.
 44. { " " side entrance.
 " self-cleansing trap.
 " loose top ; square seat.
 " combination gully.
 { Doulton's square type gully ; not a self-
 cleanser.
 { Cast iron ball valve tidal gully.
 { Turner and Croker's patent gully and channel
 blocks.

Gullies should be of the self-cleansing type. Those with a square seat are more likely to be properly fixed than those with a round one.

All gully traps should be set on concrete. If loose tops are used the joint between the top and the trap should be carefully made.

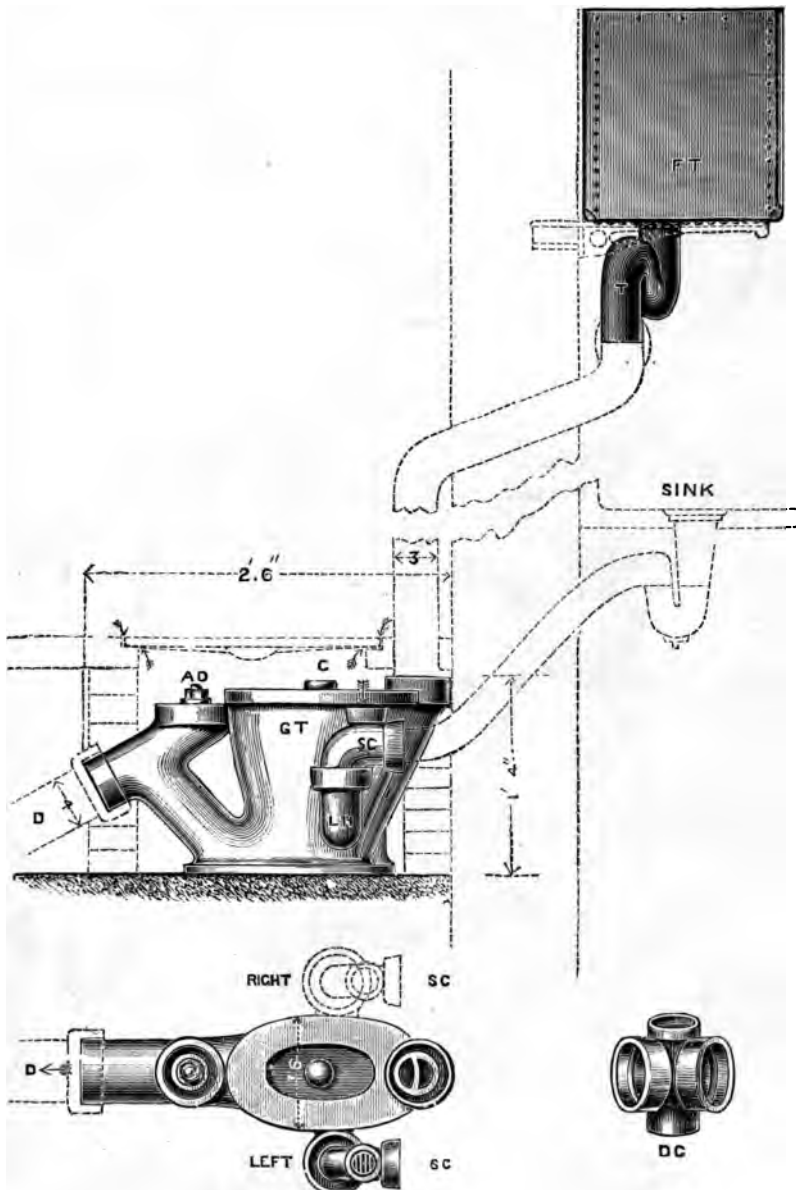
GREASE TRAPS

These are of two types—the one with a flushing rim supplied by an automatic flushing tank with water sufficient to break all the grease up into pieces and thoroughly flush same through drains to sewer.

The other type is simply a collector which requires emptying regularly by hand.

Hellyer's grease trap section and models.

Doulton's " " "



Hellyer's Flushing Run Grease Trap

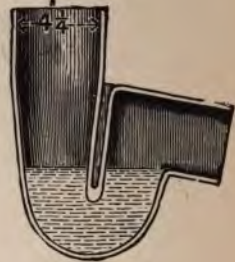
HELLYER'S ANTI D TRAPS (CAST LEAD)



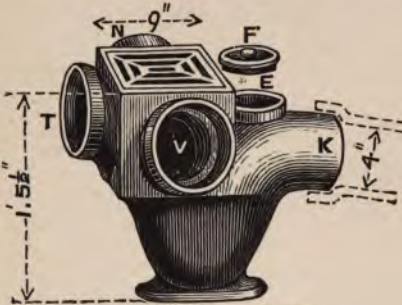
A.—For W.Cs.



For Baths, etc.



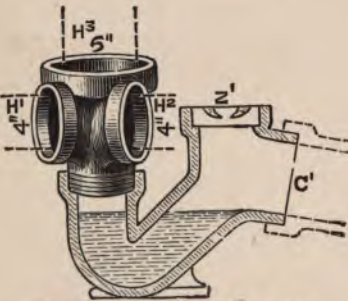
Section of A



Earthenware Interceptor



For Sinks, Baths, etc



Earthenware Interceptor, with movable connecting piece



Lavatory Trap



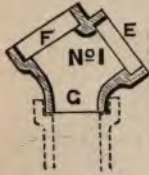
Lavatory Trap, with enlarged mouth



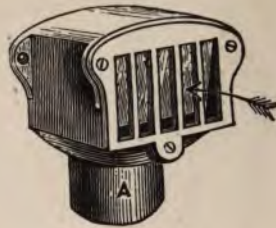
Hellyer's Inlet



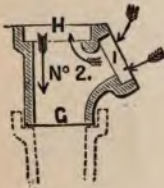
Grating



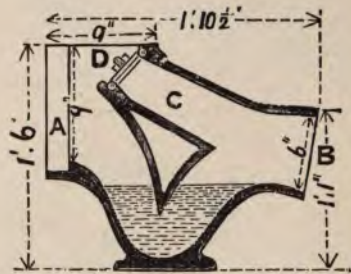
Mushroom Vent



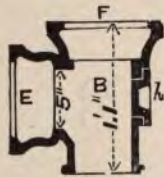
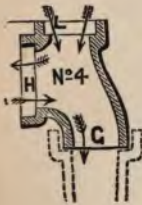
Mica Flap Vent



Ventilating Pipe



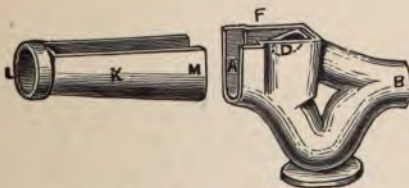
Section Interceptor



Cast Iron Lengthening Piece

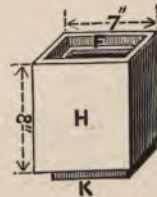


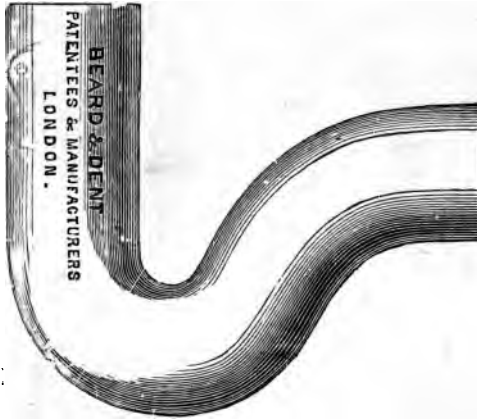
Chamber Invert



Chamber Invert

Interceptor

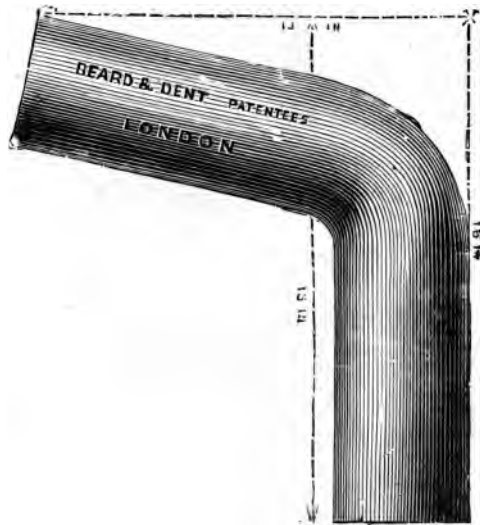




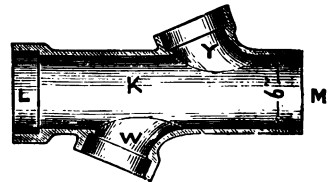
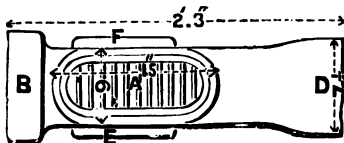
Cast-lead P Trap



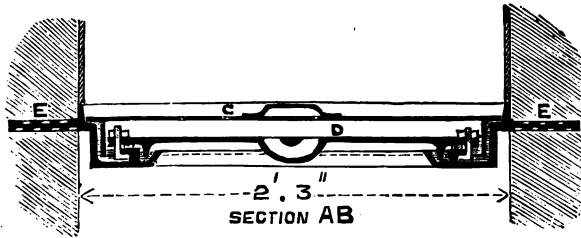
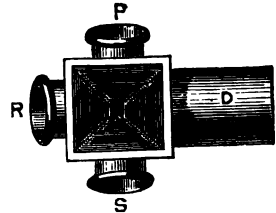
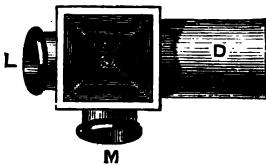
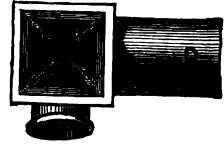
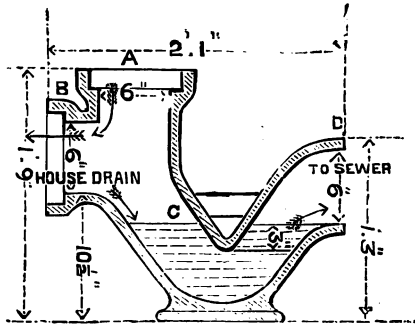
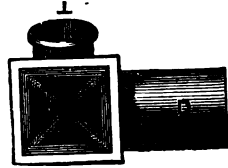
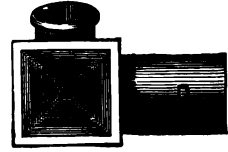
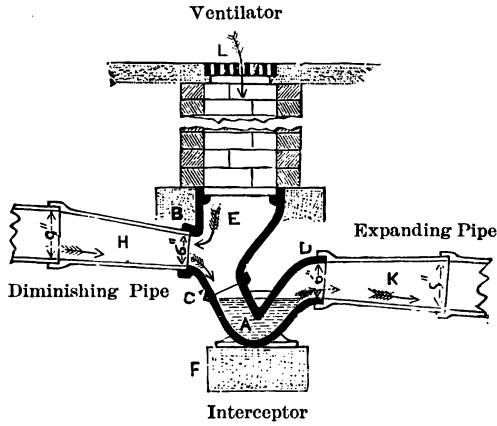
Cast-lead S Trap, with
Cleansing Screw



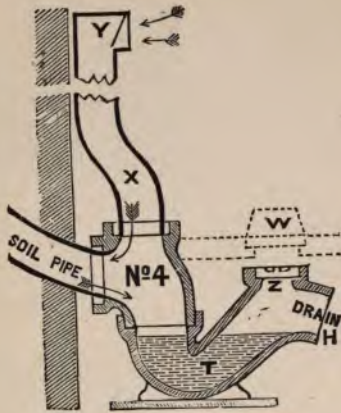
Cast-lead Bend



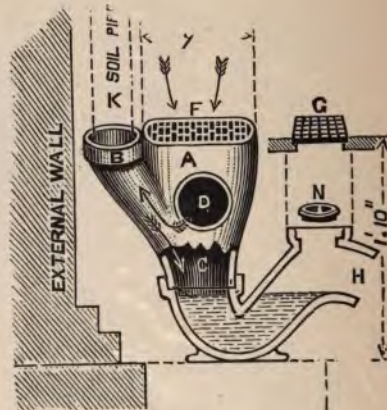
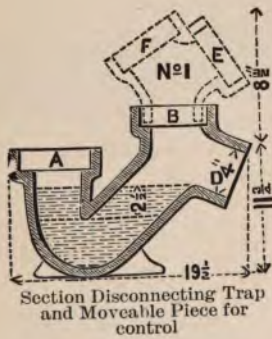
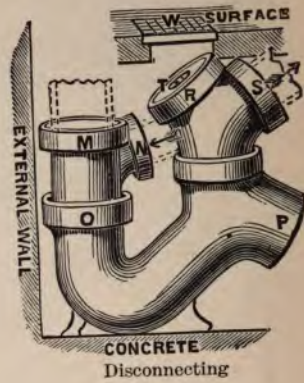
TYPE OF INTERCEPTOR



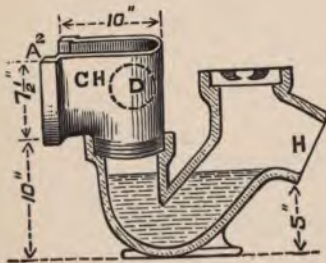
Double Luted Cover to drain Access Chamber



Section of Disconnector



Disconnector for receiving Vertical or Outside Soil-pipe



SINKS

White glazed kitchen or scullery sink with drainer on fireclay pedestals.

LEAD TRAPS, PIPES
WATER FITTING AND SUPPLY

Supply required for various purposes :—

Domestic, 17 to 20 gallons per head per day.

Cottages with dry earth system, 10 gallons per head per day.

Hospitals, 25 gallons per head per day.

Barracks 16 " " "

Stables 16 " per horse.

" 10 " per two-wheeled carriage.

" 12 " per cart or waggon.

" 16 " per four-wheeled carriage.

Cattle houses 10 " per cow.

" 1 gallon per sheep or pig.

In manufacturing towns, 30 gallons per head of population.

Cisterns should hold two to three days' supply when service is intermittent, and one day's supply when constant.

Average rainfall, 20 inches per annum each square inch of surface.

One inch of rainfall per yard super = about $4\frac{1}{2}$ gallons. If rainwater is the source of supply, provide for four months.

Average required *only* indicated by above.

Supplementary value of rain, watering, and flushing.

In case the service pipes are of lead they are required to be of the following strength, viz. :—

$\frac{3}{8}$ inch diameter	...	5 lbs.	per lineal yard.
$\frac{1}{2}$ " "	...	6 lbs.	" " "
$\frac{3}{4}$ " "	...	9 lbs.	" " "
1 " "	...	12 lbs.	" " "
$1\frac{1}{4}$ " "	...	16 lbs.	" " "

LEAD TRAPS, PIPES, AND WATER FITTINGS

45. { Drawn lead, P trap.
 " " S trap.
 " " Pipe.
 " " ,, with branches wiped on.
 Bower trap.

LEAD TRAPS

CASEMENT LIGHTS AND WINDOW

VENTILATORS

The air inlets are—

Boyle's
 Sherringham's
 Gibbs's

EXTRACTORS

Blackman fan, electrically driven.
 Boyle's cowls for soil pipe.
 „ air pump ventilators.
 Gibbs's air pump ventilators.

ROOM B

Models shewing angles, and illustrating Liverpool
Bye-laws as to space.

WALL COVERINGS

Three coat work on lath.

„ „ expanded metal.

„ „ fibre slab.

Fibrous mouldings.

BUILDING MATERIALS

SPECIMENS OF FLOOR FORMATION

HOT WATER CYLINDERS

WOOSEY PATENT ANTI-SYHONIC CYLINDER

COLLAPSED CYLINDERS

FAULTY JOINTING

ROOM C

Water-closet basins should be so constructed that the trap is effectively flushed by the contents of the flushing cistern attached thereto.

The types illustrated by working models are :—

The valve.

The wash down.

The syphonic.

The short hopper.

The ' waste water ' system.

The models of the pan closet with defective cistern arrangement ; the defective soil pipes and D traps are placed prominently, and are intended to indicate the type of sanitary fittings now universally condemned.

Flushing cisterns should contain not less than three gallons, and may be of the

Single valve,

Compound,

or Syphonic type.

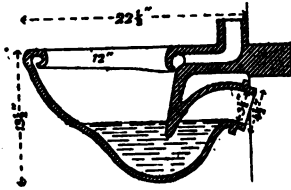
The automatic cistern is the fitting adopted to ensure systematic flushing in public urinals.

The best workmanship is needful to ensure satisfactory fixing of water-closet basins and the attendant fitting.

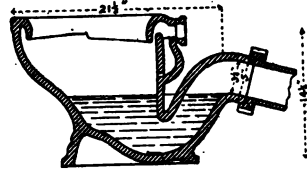
Lead safes should be fixed on all wood floors on which slop sinks or water-closet basins are to be fixed.

The walls and floors of rooms set apart for their accommodation should be of impervious material.

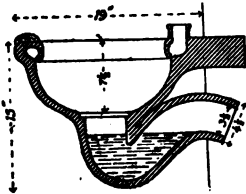
Much mischief is wrought by woodwork becoming saturated with liquid filth.



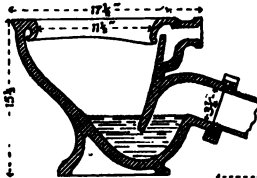
"Console" Washdown
W.C. Basin.



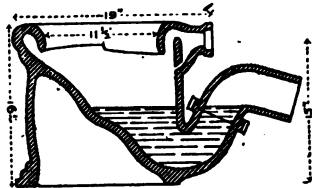
"Planetas-Hospital,"
W.C. Basin.



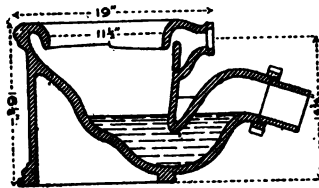
"Console" Hospital
Slop Hopper.



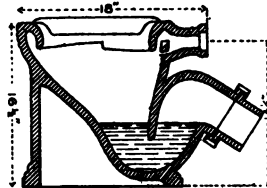
"Planet-Hospital,"
W.C. Basin.



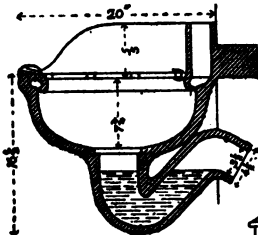
"Axis-Hospital,"
W.C. Basin.



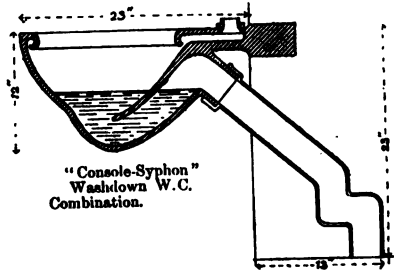
"Orion-Hospital,"
W.C. Basin.



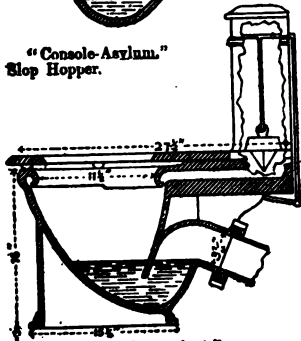
"Zone-Hospital,"
W.C. Basin.



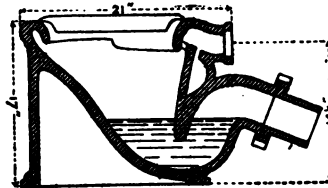
"Console-Asylum,"
Slop Hopper.



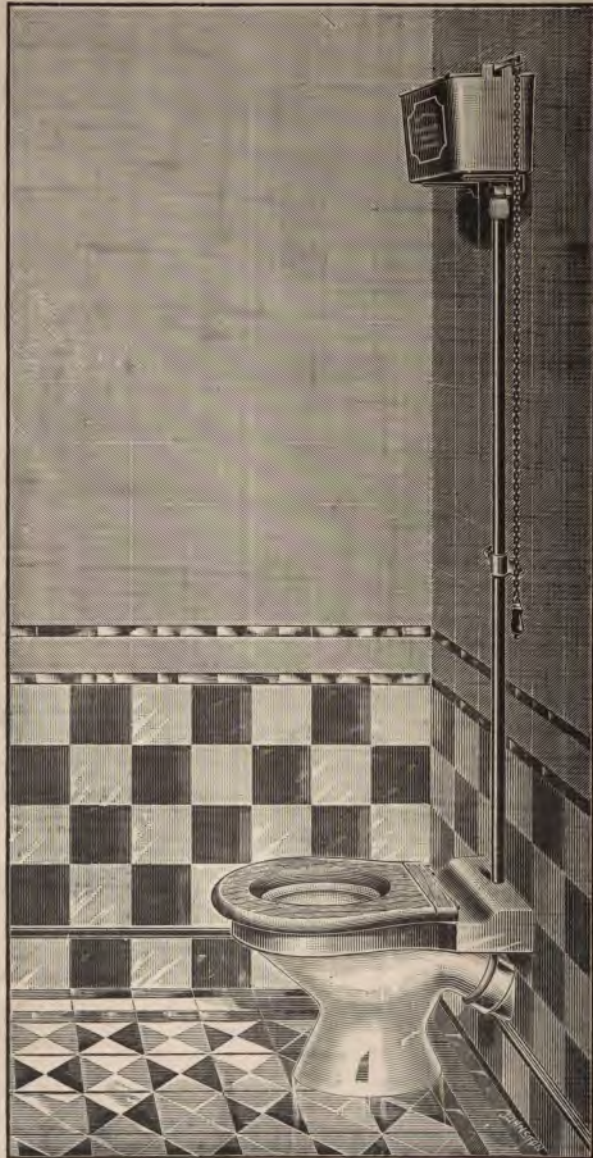
"Console-Syphon"
Washdown W.C.
Combination.



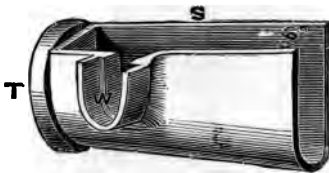
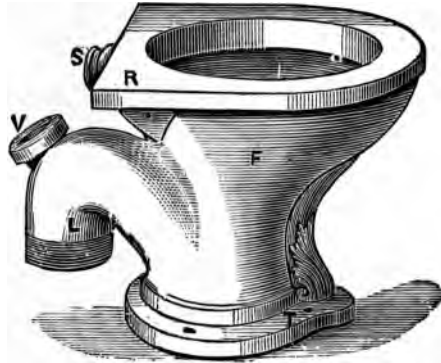
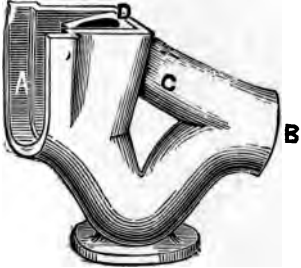
"Ideal Convenient,"
with self-raising seat and
seat action fittings.



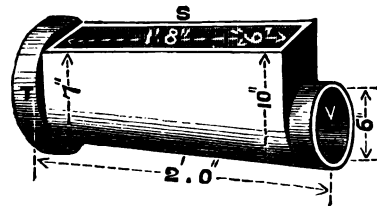
"Deluge-Adamant"
Hospital W.C. Basin.



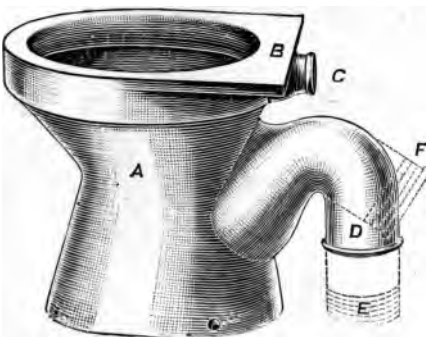
Hellyer's Patent Fireclay 'Neat' Pedestal Washdown
with extended top
Illustrating compact arrangement of W.C.



Hellyer's Air Shaft (2 ft. long)
for 6 in. Drain



Junction Channel for Access Chamber

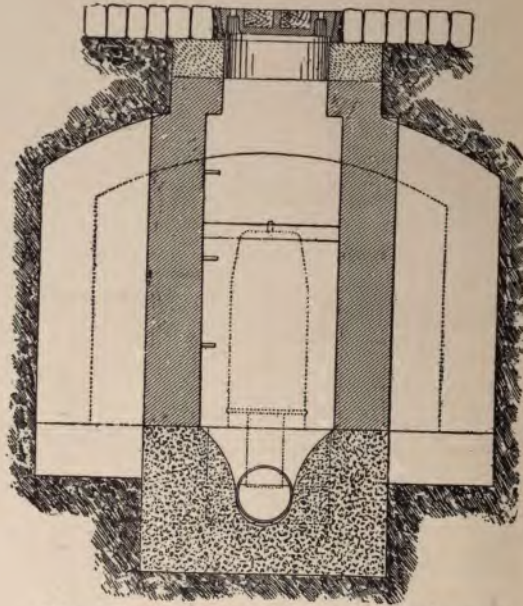


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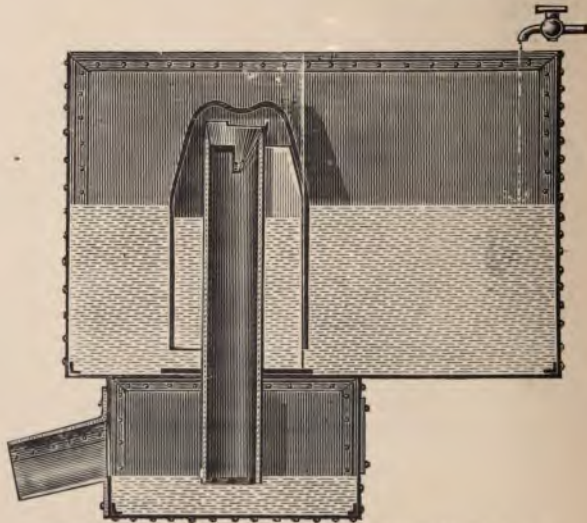


Cast lead Cone for fixing
on inlets of P & S Traps

SEWER FLUSHING APPLIANCES

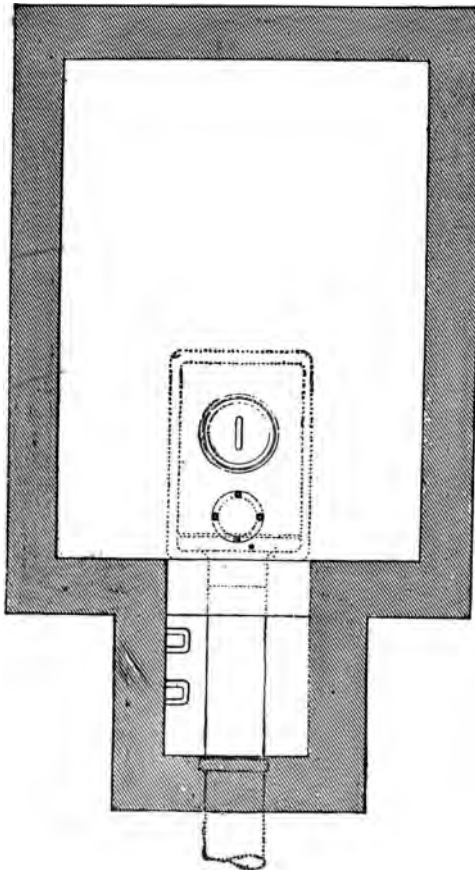
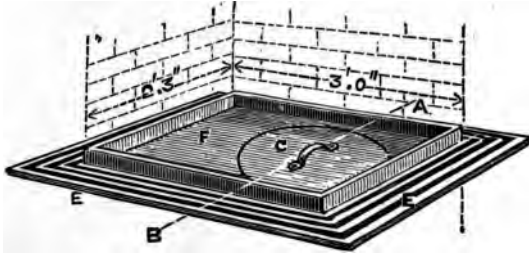


'Roger Field' Flushing Syphon, in iron, for house use

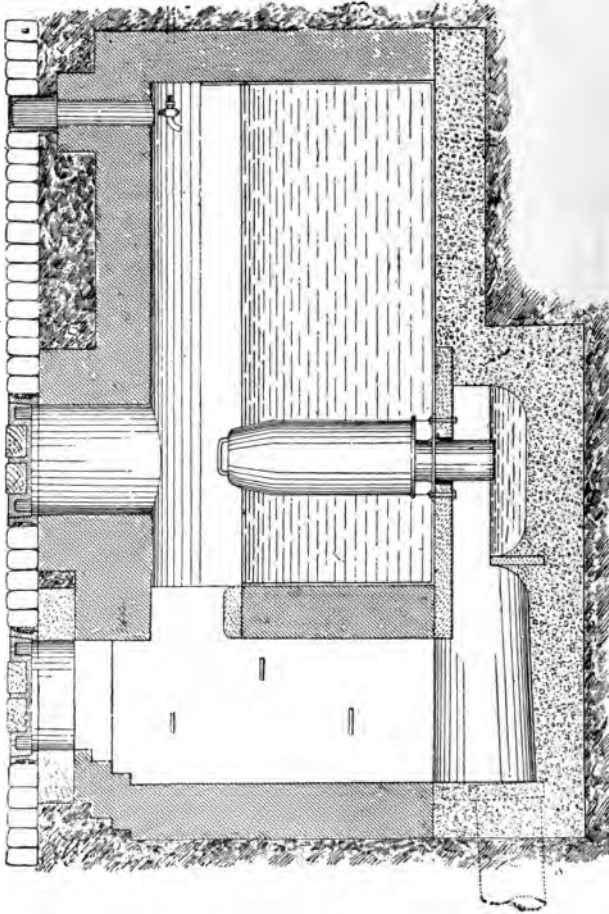


Transverse Section 'Roger Field' Syphon in Carriageway

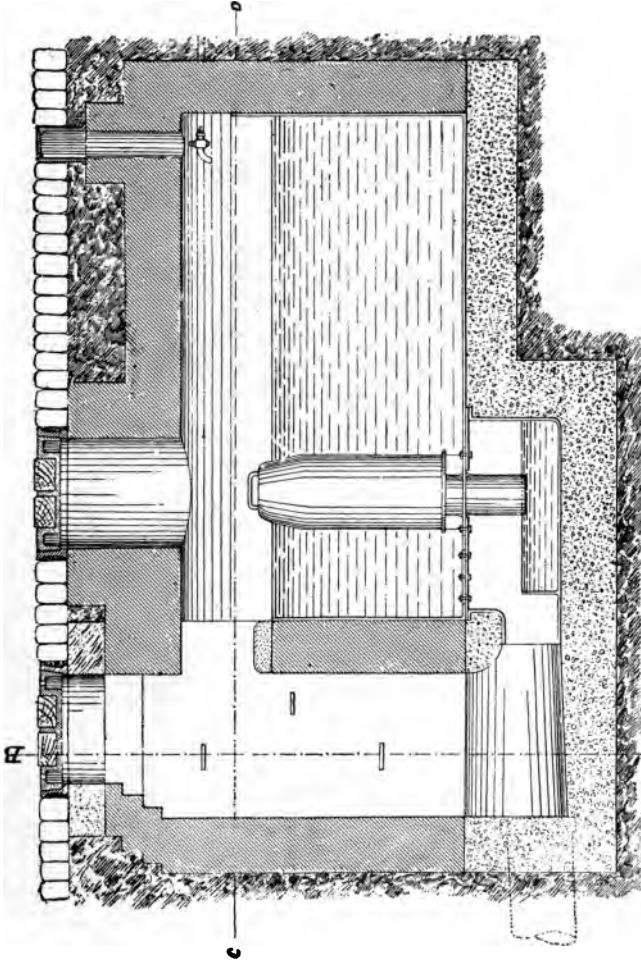
SEWER FLUSHING APPLIANCES



Plan Roger Field Syphon
in Carriageway



Longitudinal Section 'Roger Field' Flushing Syphon in roadway with Flag Weir



Longitudinal Section 'Roger Field' Syphon for Flushing Sewers with Iron Box Weir

The increased use of concrete floors for that portion of buildings set apart for sanitary purposes is a great gain.

The use of tiling for covering wall surfaces is to be recommended.

Adequate window area and free ventilation are indispensable in connexion with these rooms.

Water closets are best fixed in a room by themselves—adjoining, but not in, a bath room.

The methods of constructing impervious partitions by means of brickwork and cement rendering—the ‘Cunnah Wright’ fireproof system of iron lathing and small H iron sections covered with Portland cement rendering—the ‘Thilmill’ and ‘expanded metal’ systems similarly covered are all great advancements.

One type of earth closet is shown.

CORRIDORS

WALL COVERINGS

Hand-made papers rendered washable by special process—five examples.

Machine-printed sanitary wall papers.

Dado and frieze anaglypta.

Japanese leather papers.

Case showing stages of wall paper manufacture.

VESTIBULE

Tynecastle vellum.

Duresco, washable and anti-damp.

Anaglypta, relief material painted in enamel.

Tynecastle canvas decorated in enamels, non-porous and washable.

Stencil decorations in oil colours.

Embossed material decorated in colours and washed over to prevent absorption.

Painted surface with stencilled powderings in oil colours.

Salamander relief decorations, fire-proof and sanitary.

Embossed leather paper lacquered.

Painted surface with decorated frieze in oil colours.

Lincrusta Walton solid relief decorations.

LABORATORIES

Chemistry and Bacteriology, as applied to Public Health.

Apparatus and chemicals for the analysis of water.

Kock's sterilizer.

Autoclave.

Incubators.

Microtomes.

Microscopes.

Various apparatus for the chemical and bacteriological examinations of water and foods.

LECTURE THEATRE

Capable of accommodating fifty or sixty students.

Provided with electric lantern and a large number of slides illustrating various sanitary subjects ; also a number of diagrams, drawings, and tables suitable for lecture purposes.

SPECIMENS

A collection of Comparative Pathology specimens, illustrating the diseases of animals used for human food. Shown in cases in Lecture Theatre.

- | | |
|-----|--|
| No. | |
| 9. | Liver from calf, aged one month. Necrotic abscesses. |
| 12. | Tuberculosis. Liver from cow; lung also extensively affected. Animal in good condition when slaughtered. |
| 15. | Tuberculosis. Ribs with pleura, from pig; lungs also extensively affected. B. Tuberculosis found. Good example of the term 'Grapes.' |
| 16. | 'Farcy buds.' Horse. Section of skin inside thigh. |
| 17. | Glanders. Nasal septum from horse, showing ulcers. B. Mallei found. |
| 19. | Swine Fever. Intestine, part round ilio-caecal valve. Ulceration of Peyer's patches. |
| 21. | Swine fever. Intestine. Widespread ulceration. |
| 25. | Cysticercus Cellulosae. Shoulder of pork ('Measles'). |
| 39. | Tuberculosis. Lung from pig. B. Tuberculosis found. |
| 40. | Pig. Malformation of foot. |
| 41. | Kidney from bullock. Fatty degeneration. |
| 42. | Liver from ox. Chronic pyaemic abscesses. |
| 43. | Cystic kidney from pig. |
| 44. | Actinomycosis. Section of tongue from ox. |
| 45. | Pericarditis. Section of heart from ox. |
| 46. | United fracture of rib from pig. |

- 49 Nodular disease of intestine from sheep. Found
and only in sheep from South America. Due to
- 49A. parasite *Eosophagostoma Columbianum*,
 found in the nodules.
- 54. *Cysticercus Cellulosae*. Heart of pig.
- 56. Mammitis. Cow. Shows large abscess.
- 60. Fowl's head. Atheromatous cyst.
- 61. *Cysticercus Cellulosae*. Heart of pig.
- 63. Actinomycosis. Lower jaw of ox.
- 64. Avian Tuberculosis. Liver of fowl ; intestines
 and spleen also affected. Disease probably
 originated in intestines. B. Tuberculosis
 found.
- 68. Stomach of goat, showing *Trichocephalus Dispar*.
 or Whipworm.
- 75. Tuberculosis. Spleen of calf, aged five months.
 Animal probably affected after birth. B.
 Tuberculosis found.

**USEFUL TABLES AND
MEMORANDA**

USEFUL TABLES AND MEMORANDA

WATER

1 cubic foot of water...	...	...	=	62.425 lbs.
1 do. * do. ...	...	...	=	6 $\frac{1}{4}$ gallons (nearly)
1 gallon ...	...	...	=	10 lbs.
Head of water in feet \times 62.42	...	...	=	pressure in lbs. per square foot of surface.
Do. do. \times .4335	...	...	=	do. do. per square inch.
Diameter of pipe squared \times .7854	...	...	=	Area of cross section.
Diameter of pipe in inches squared \times .034	...	...	=	Gallons per foot run.
Diameter of pipe in inches squared \times .34	...	...	=	Weight of water in lbs. per foot lineal.
Area of tube \div 2.31	...	...	=	do. do.
Pressure in lbs. per square inch \times 2.31	...	...	=	Head of water in feet.
Area of cistern. Sides and bottom in feet \times { half depth of water in feet \times 62.42	...	...	=	Total pressure in lbs.
1 foot of water one inch square	...	...	=	.4335 lbs. pressure on square inch.
$\frac{1}{8}$ th inch of Rainfall is equal to .585	...	...	=	gallons each superficial yard of surface.
Rainfall in inches \times 0.52	...	...	=	Gallons per square foot.
Do. do. \times 22,620	...	...	=	Gallons per acre.
Do. do. \times 3,630	...	...	=	Cubic feet per acre.
Do. do. \times 2,323,200	...	...	=	Cubic feet per square mile.
Do. do. \times 14 $\frac{1}{2}$	...	...	=	Millions of gallons per square mile.

Weight of cast iron pipes per 9 feet length (9 feet 4 inches including socket).

		CWT.	QRS.	LBS.	
3	=	1	0	14	$\frac{3}{8}$ inch metal.
4	=	1	2	0	$\frac{3}{8}$ do.
5	=	2	0	0	$\frac{3}{8}$ do.
6	=	2	2	0	$\frac{1}{2}$ do.

CALCULATION OF DISCHARGE FROM SEWERS

$$V = 55 \times \sqrt{D \times 2 F}.$$

Where V = velocity in feet per minute.

D = hydraulic mean depth in feet.

F = Fall per mile.

Then if A = sectional area of current of fluid, VA = discharge in cubic feet per minute.

Volume of sewage, etc., per day, per house, usually taken as 175 gallons.

Sewers are usually provided for 1,000 gallons from each house.

WETTED PERIMETER

In an open channel or pipe not flowing full, that portion of the channel or pipe wetted by the liquid is called *wetted perimeter* or *border*

All drains must be at least twice their diameter below basement floors, where they are forced to be used in such situations.

HYDRAULIC MEAN DEPTH

is the sectional area of the fluid divided by the wetted perimeter,

or

Area EBF
Length EBF

They should also be of iron caulked with lead, and embedded in six inches of good cement concrete.

To find fall in drain pipes necessary to give approximate velocity of 278 feet per minute, multiply drain in inches $\times 10$.

Great care should be taken in laying and filling over pipes. The best of work is often spoiled by careless filling up.

SELF-CLEANSING BOTTOM VELOCITIES

(BEARDMORE)

·50 feet per second = 30 feet per minute will not disturb clay with sand and stone.

·6 do. do. = 40 do. do. will move along coarse sand.

1·0 do. do. = 60 do. do. will move fine gravel size of peas.

2·0 do. do. = 120 do. do. will move rounded pebbles 1 inch diameter.

3·0 do. do. = 180 do. do. will move angular stones $1\frac{3}{4}$ inch diameter.

In sewers *self-cleansing* velocity should never be less than 2 feet per second.

Ratio between top and bottom velocity (generally) may be taken as 3 to 5.

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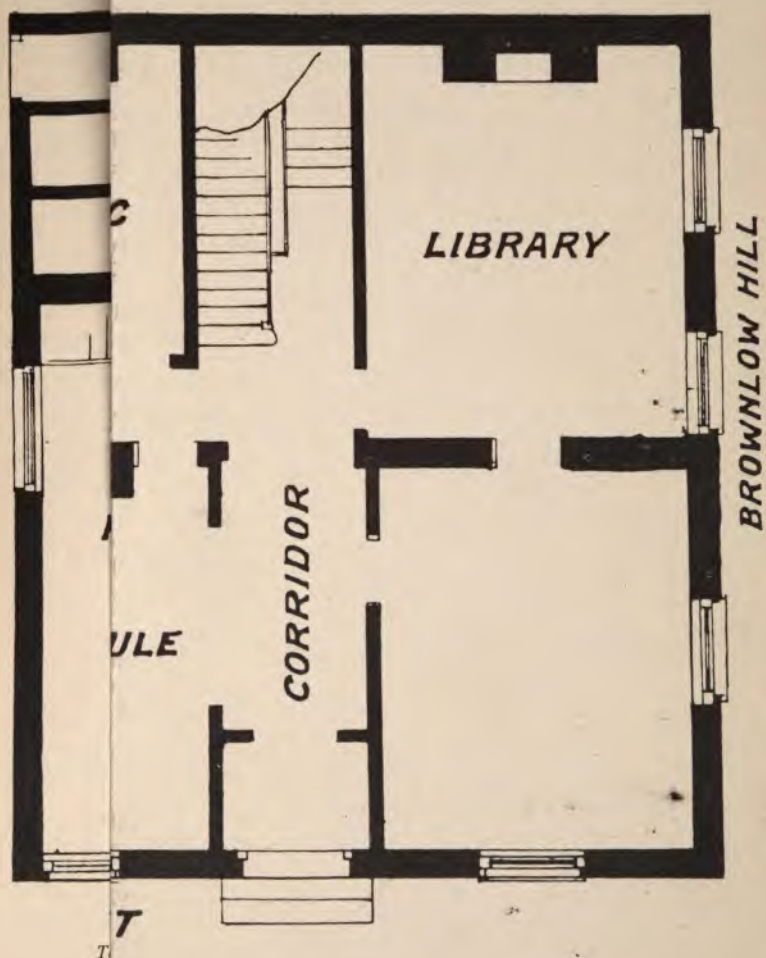
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